DEPARTMENT OF COMMERCE

TECHNOLOGIC PAPERS
OF THE
BUREAU OF STANDARDS

S. W. STRATTON, DIRECTOR

No. 40
THE VERITAS FIRING RINGS

BY

A. V. BLEININGER, Ceramic Chemist

and

G. H. BROWN, Associate Ceramic Chemist

Bureau of Standards

[JUNE 5, 1914]

WASHINGTON
GOVERNMENT PRINTING OFFICE
1914

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THE VERITAS FIRING RINGS

By A. V. Bleininger and G. H. Brown

The object of the present work is the investigation of the influence of temperature upon the firing rings used in the "Veritas firing system," which is employed in a considerable number of potteries and other clay plants. These rings are placed in several parts of the kiln and withdrawn at different times during the firing. Their shrinkage gives an indication of the progress of firing. The rings are made of a clay body, approaching white ware very closely in composition, and are 2.5 inches in diameter and have an opening about 0.85 inch in diameter. They are made by pressing the clay body in the condition of moist dust, using a steel die and a screw press. The diameter of the ring is determined by means of a simple measuring device, in which the ring is held against two pegs by a lever pressed forward by a spring. The ring is thus held in position by three points. The extremity of the lever, which is about 8⅝ inches in length, moves along a scale, which is graduated into 60 equal divisions in an arc about 2⅞ inches in length. Any change in diameter is indicated in a magnified degree by the displacement of the pointer along the scale. The principle involved is, of course, not new and was employed most admirably about 140 years ago by the famous potter, Josiah Wedgwood, in the form of the pyrometer with which his name is associated. Many other similar devices have been proposed, and it is a well-known fact that shrinkage measurements have been used in the brick industry for many years as the most useful criterion of the progress of vitrification.

The present device was first described in detail by Marc Solon,[1] the inventor. Mr. Solon, in the article referred to, does not claim

[1] The Pottery Gazette, Oct. 1, 1905.

any great novelty in the principles of his method, but states that its advantages consist, first, in being able to determine the progress of the firing at any time by the withdrawal of rings from certain parts of the kiln, so that uniformity of burning may be maintained; secondly, the shrinkage numbers indicate the actual heat work being done upon the body, so that the rate of firing may be accelerated during the period when little contraction is taking place and retarded when shrinkage is proceeding at its maximum rate. In this manner the firing may be adjusted to the requirements existing at any time, which would not be possible by the use of a pyrometer unless the most suitable rate of firing were previously determined. It is evident that, like the pyrometric cones, the firing rings can not indicate temperatures. The more rapid the rate of firing the higher must be the temperature corresponding to the different shrinkage numbers, and vice versa. At the same time, however, it would seem desirable to correlate the indicated contraction values with the temperatures for different rates of heating in order to connect the use of these trials with pyrometer practice. This is the object of the present work.

One of the requirements of a standard of this kind, where the same composition is to be used in plants making all sorts of products and using many kinds of clays, must be a practically uniform rate of contraction, for it is evident that any decided irregularities in this respect would tend to diminish the accuracy and usefulness of the system. Such fluxes as lime must, therefore, be avoided in the body used for these test specimens. The best mixture would probably be that of a white ware body in which the predominating flux is feldspar. Such a body is composed of about 52 per cent of clay substance, 33 per cent of flint, and 15 per cent of feldspar. By increasing the amount of feldspar the range of the scale may be readily extended to porcelain.

In the preparation of such standards it is necessary also to have available large quantities of the raw materials, thoroughly mixed, so that no undue variations may occur. Such factors as the fineness of grain of the feldspar and flint must be maintained constant, as well as the methods of preparation and pressing. Any decided change in the raw materials would make it difficult

to coordinate new mixtures with the old one, as the rate of contraction might be changed. However, by careful experimenting it should be possible to produce stock the properties of which would check with those of the standard mixture.

Forty of these rings were calipered with a micrometer and the average diameter found to be 2.5065 inches. Measurement showed slight deviations from the circular shape but not sufficiently great to be corrected for in this work. The largest deviation in diameter was 0.0012 inch and the mean deviation 0.0004 inch. The weight of the rings varied from 48.55 to 50.70 grams, their thickness being, of course, of no consequence. The measuring scale has five divisions to the left of the zero point, so that somewhat larger rings than the standard size may be measured, although the specimens of each shipment are always of the same caliper. Each division of the scale corresponds to a mean value of 0.0054 inch, as measured upon the specimen. Measurements of the scale by means of a microscope comparator showed considerable and irregular variations in the graduation. The measurements of the rings in practice could be made with a device capable of greater accuracy, such as a modified micrometer caliper.

In determining the shrinkage of the rings at different temperatures the question of rapidity of firing was taken into consideration, and four firings were made at the constant rates of increase of 12.5, 16.6, 25, and 50° C per hour. The burns were made in one of the gas-fired test kilns of the laboratory, having a capacity of about 28 cubic feet. The temperature was controlled carefully by means of two thermocouples, one of which was connected to a recording and the other to a nonrecording Siemens-Halske millivoltmeter. The cold junctions were kept at the ice point. A suitable opening was provided in the wicket for the removal of the rings, two of which were taken out at each drawing temperature. Upon cooling, the rings were measured by means of a micrometer reading to 0.0001 inch and the instrument furnished by the manufacturer. Three readings were taken of every ring and the average of these used. The results of this work are compiled in Table 1.

TABLE 1

Veritas Firing System—High Fire Disks

	Burning shrinkage (inches)				Shrinkage number			
Temp. °C	Rate, 50° per hour	Rate, 25° per hour	Rate, 16⅔° per hour	Rate, 12½° per hour	Rate, 50° per hour	Rate, 25° per hour	Rate, 16⅔° per hour	Rate, 12½° per hour
1010	0.0110	0.0124	0.0191	0.0208	1.37	1.50	3.00	3.50
1030	.0175	.0184	.0257	.0263	2.5	2.50	4.12	4.50
1050	.0279	.0303	.0403	.0395	4.37	5.00	7.12	7.00
1070	.0427	.0499	.0595	.0647	7.50	9.20	11.00	11.87
1090	.0636	.0746	.0785	.0823	11.75	13.75	14.75	15.87
1110	.0815	.0945	.1034	.1041	15.00	18.00	19.25	19.75
1130	.1035	.1183	.1205	.1201	19.50	22.25	23.00	23.00
1150	.1325	.1404	.1416	.1418	24.87	26.12	26.62	26.75
1170	.1525	.1571	.1680	.1656	28.75	29.25	31.12	30.75
1190	.1666	.1699	.1892	.1895	31.00	31.50	35.00	34.87
1210	.1863	....	.2056	.2061	34.50	....	37.75	38.00
1230	.2018	....	.2198	.2175	37.12	....	40.00	40.00
1250	.2165	....	....	.2297	39.75	....	....	41.75
1270	.2285	....	....	....	41.50	....	....	....

These values are also presented in graphic form in Figs. 1 and 2, in which the shrinkage is expressed in the numbers of the Veritas instrument and in inches, as measured by means of the micrometer caliper.

From the curves it appears that the rate of shrinkage is quite regular and that hence the composition answers the purpose for which it is intended very satisfactorily. Measurements were not taken at lower temperatures as these changes, as far as a body of this kind is concerned, are of no particular importance. It might be stated also that the instrument shows very distinctly that expansion occurs coincident with dehydration, though this point is not one of special significance as far as the control of burning is concerned. Upon comparing the four curves it will be noted that the time factor manifests itself in quite a marked manner, the temperatures at which equal contraction takes place being the higher the more rapid the rate of firing. These differences seem to diminish as the temperature rises. The firings at the rate of 12½ and 16⅔° per hour tend to coincide, as is to be expected, since the heat absorption approaches a constant value.

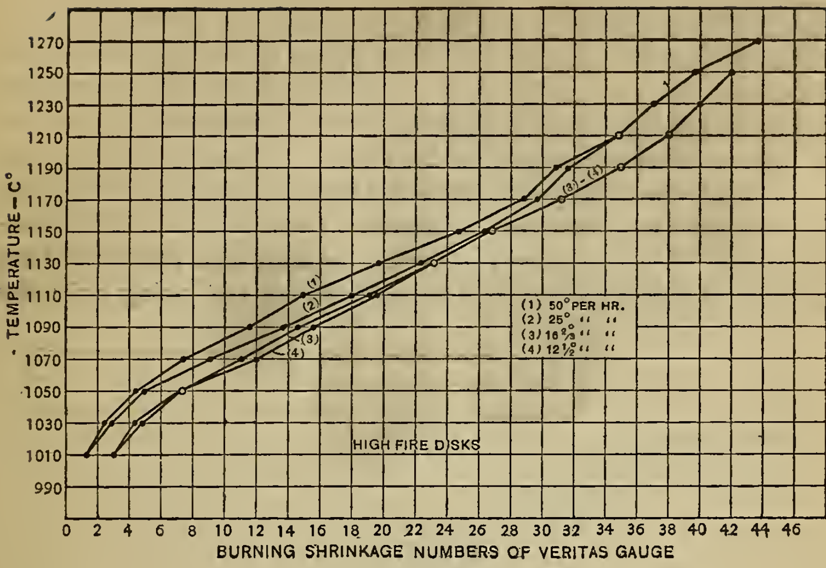
TEMPERATURE — C°
1270
1250
1230
1210
1190
1170
1150
1130
1110
1090
1070
1050
1030
1010
990
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46
BURNING SHRINKAGE NUMBERS OF VERITAS GAUGE
(1) 50° PER HR.
(2) 25° " "
(3) 16⅔° " "
(4) 12½° " "
HIGH FIRE DISKS

Fig. 1

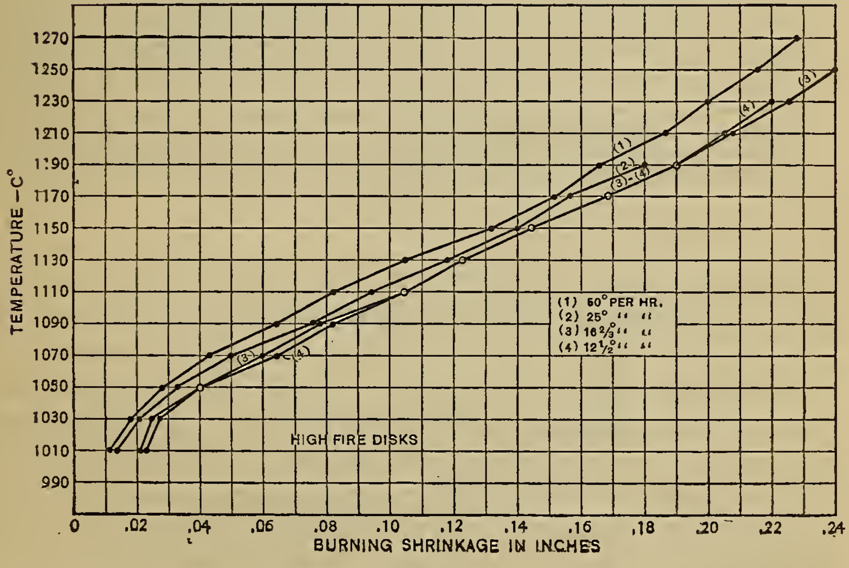
TEMPERATURE — C°
1270
1250
1230
1210
1190
1170
1150
1130
1110
1090
1070
1050
1030
1010
990
0 .02 .04 .06 .08 .10 .12 .14 .16 .18 .20 .22 .24
BURNING SHRINKAGE IN INCHES
(1) 50° PER HR.
(2) 25° " "
(3) 16⅔° " "
(4) 12½° " "
HIGH FIRE DISKS

Fig. 2

In this connection it was thought desirable also to trace the connection between the porosity and the firing temperature, at the firing rates previously mentioned, which are coordinated in the diagram of Fig. 3. These show parallelism with the contraction curves and bring out the same evidence, though the curves are differentiated somewhat more sharply.

The firm placing on the market these pyrometric firing rings has brought out also a series intended to be used at lower temperatures. A set of these was tested by a method similar to that used for the higher temperature specimens, but using only the

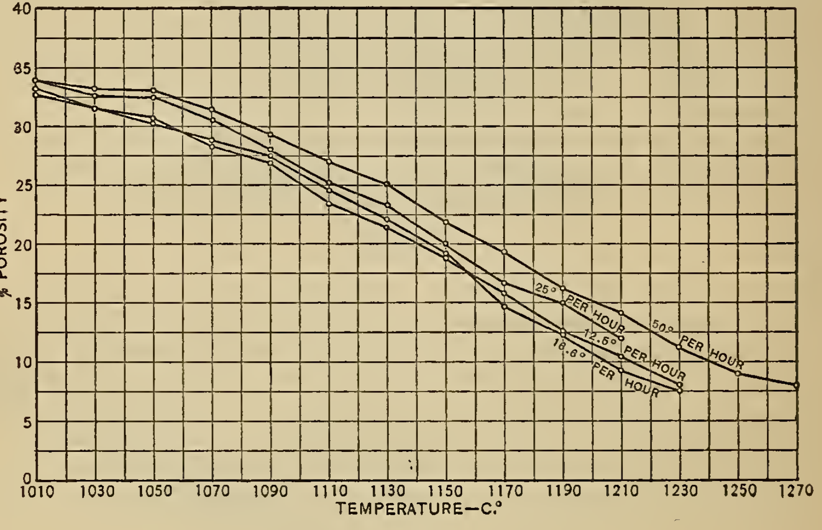

Fig. 3

12.5 and 25° per hour firing rates. The results of this work are presented in Fig. 4. From this curve it would appear that this series does not show a regular behavior throughout the temperature range in question. At least four rates of contraction may be observed. Between 950° and 1070° C the contraction progresses only very slowly, which is a serious drawback, as this particular temperature interval is a very important one for the firing of red burning clays. It would seem then that owing to this irregularity the accuracy of control would be seriously impaired within this interval, since the slight contraction indicated might

lead to the underestimation of heat effects bringing about all-important changes in the ware itself. It would be possible, however, to prepare a body which would show more consistent contraction than the one selected.

The standard firing rings of the higher temperature series are undoubtedly useful in controlling the firing of kilns, and if used in connection with a pyrometer would tend to make the latter a

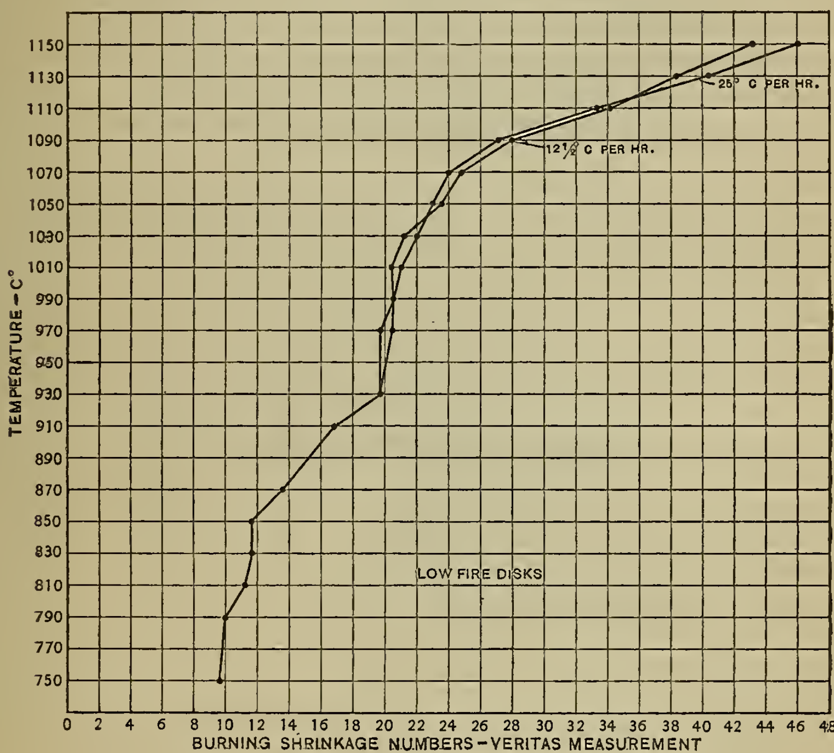

Fig. 4

far more valuable instrument. They offer a simple means of correlating heat work and the rate of temperature increase and their use in this connection would be very beneficial. The principle of the system is sound and the body selected has been well chosen for the firing of pottery kilns. The selection of the body for the lower series has not been so successful and, as has already been stated, there are serious objections to its use.

For the control of the burning of all kinds of clay ware, draw trials of this kind could be prepared from the clay or body of which the ware itself is made. It is evident that such specimens would be of greater service for determining the progress of firing than any other body. In order to make the trials comparable with each other they must of course be made from a well-mixed standard sample of the material and pressed under the same conditions. In this connection reguiarity of the shrinkage curve with temperature is not necessary, as it would be in the case of standards used in firing all sorts of clays. In fact, the very peculiarities of the contraction of such clay trials would be useful in checking the burning behavior of the same material made into ware.

Our thanks are due the Veritas Firing System Co. and the Trenton Potteries Co. for the supply of rings used in this work.

WASHINGTON, June 5, 1914.

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